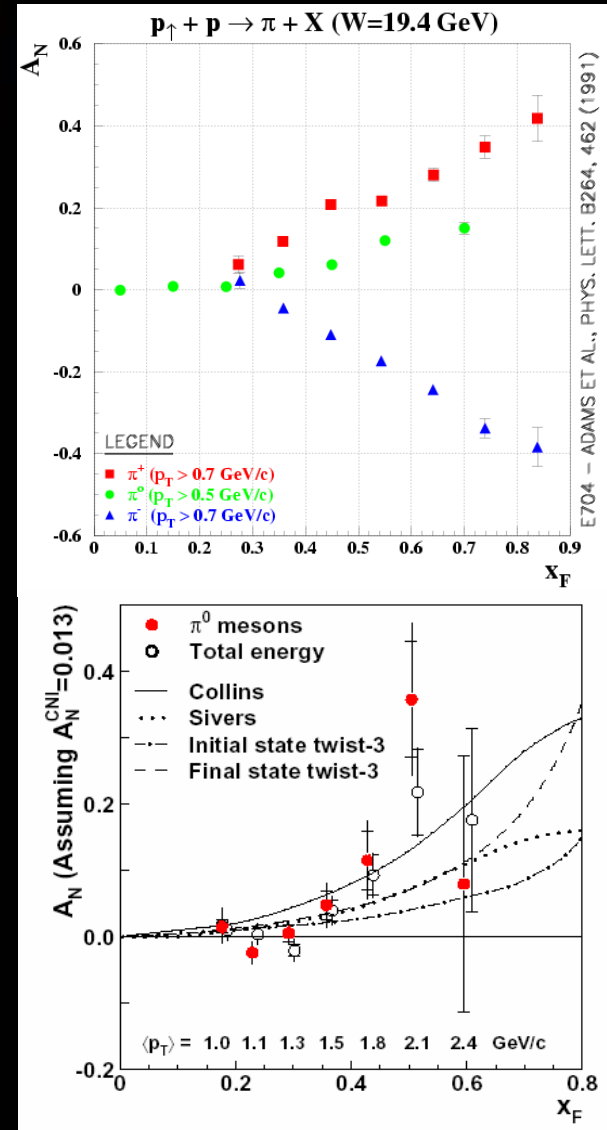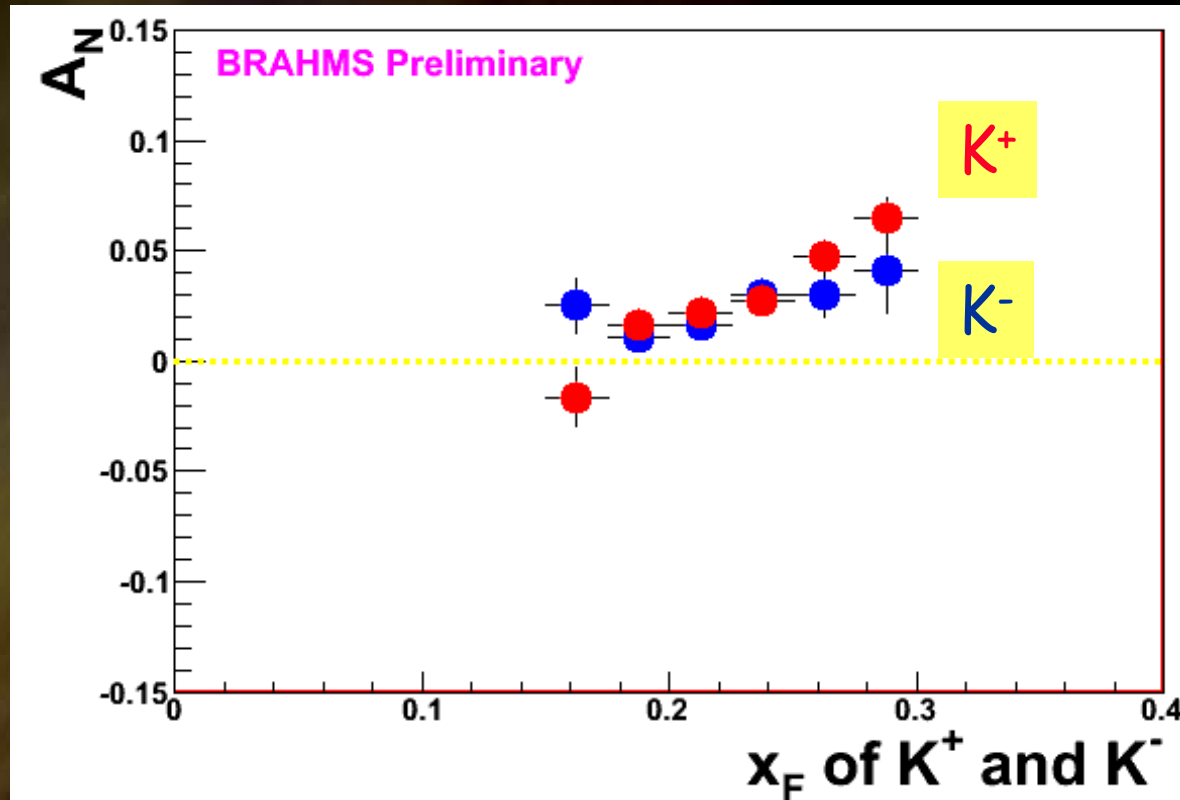# Single transverse Spin Asymmetry (SSA)

- Large SSAs have been observed at forward rapidities in hadronic reactions: E704/FNAL and STAR/RHIC

- SSA is suppressed in naïve parton models ($\sim \alpha_s m_q / Q$)

- Non-zero SSA at partonic level requires
  - Spin Flip Amplitude, and
  - Relative phase

- SSA: Unravelling the spin-orbital motion of partons?

$p_\uparrow + p \rightarrow \pi + X$ (W=19.4 GeV)

LEGEND
π^+ ($p_T > 0.7$ GeV/c)
π^0 ($p_T > 0.5$ GeV/c)
π^- ($p_T > 0.7$ GeV/c)

E704 – ADAMS ET AL., PHYS. LETT. B264, 462 (1991)

π^0 mesons
Total energy
Collins
Sivers
Initial state twist-3
Final state twist-3

$\langle p_T \rangle$ = 1.0 1.1 1.3 1.5 1.8 2.1 2.4 GeV/c

Flavor Dependent SSA: A_N of Kaons


- $A_N(K^+)$: positive ~ $A_N(K^-)$: positive ≠ 0 for $0.2 < x_F < 0.3$
- In disagreement with naïve expectations (small sea-quark polarization for K^-)
- Energy dependent A_N with 62 GeV data from Run6 with higher x_F reach

Rapidity Dependent High-p_T Measurements

0-5% centrality

π^-

BRAHMS

NA49

AGS

π^- dN/dy

y
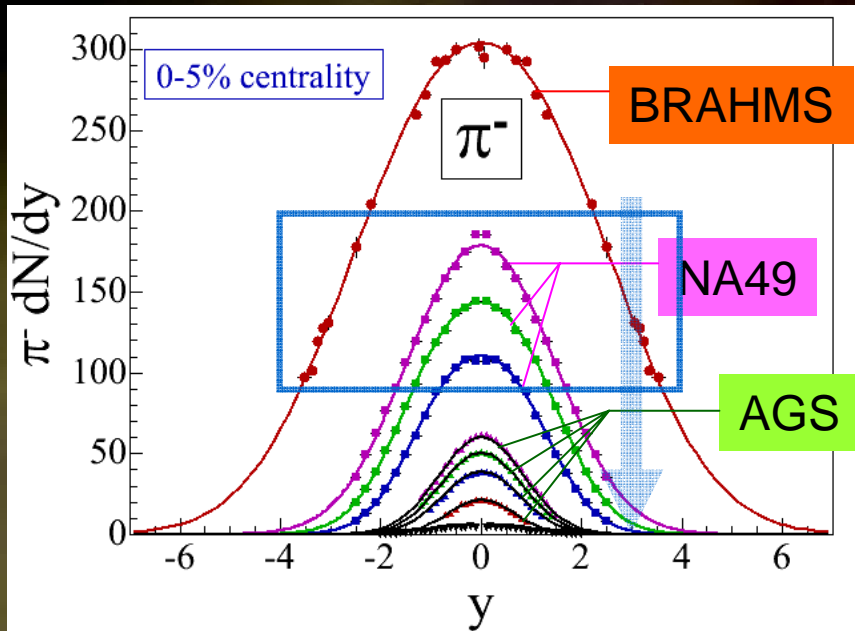
- At the RHIC energies, hard scattering processes at high-p_T become important

- Partons are expected to loose energy in the dense matter

- Different rapidities provide different densities of the medium: Sensitive to the dynamics

- "Dialing" initial condition channel

- Largest medium effect at mid-rapidity ("Scale" to multiplicity)?

- Rapidity dependent high-p_T suppression factors: provide information on dynamical medium effect
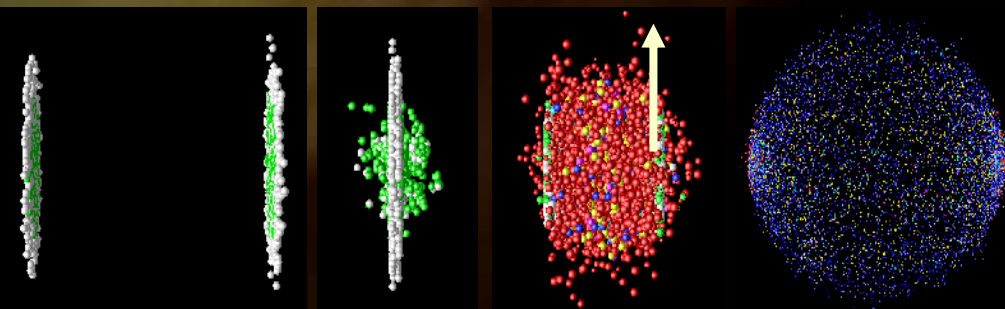
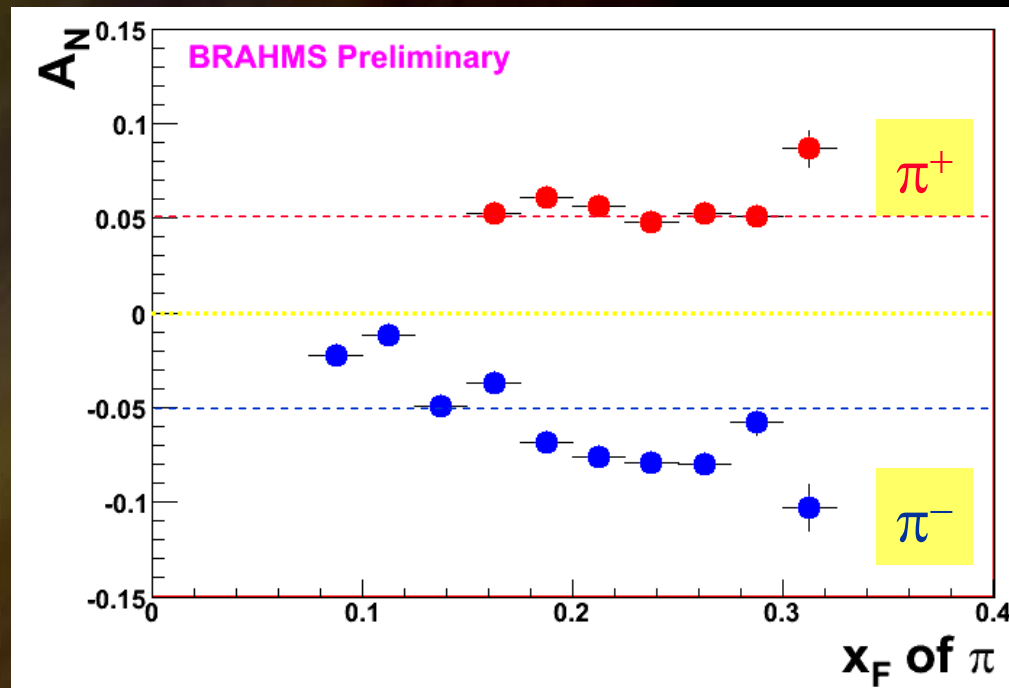# R_{CP} and R_{AuAu} vs η for AuAu @200 GeV
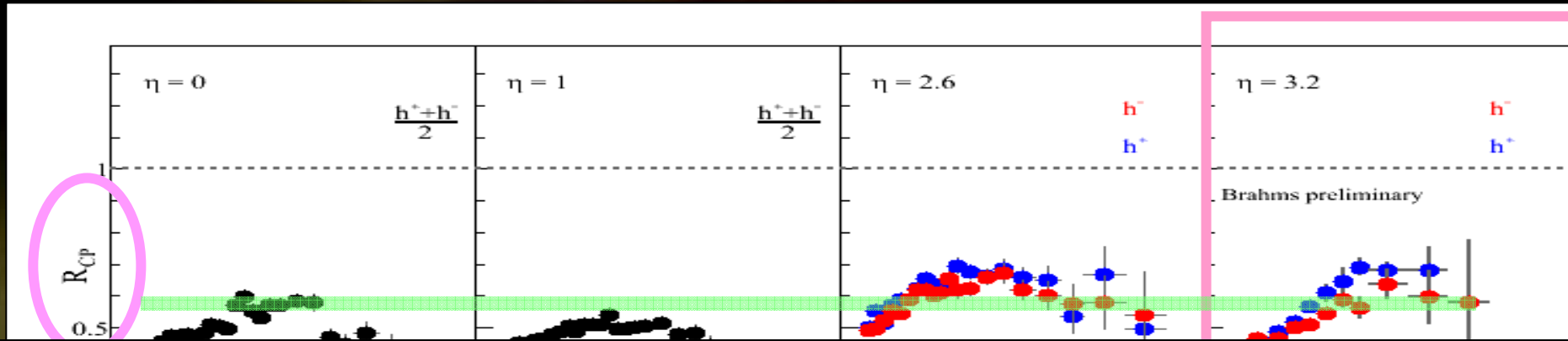
- No significant rapidity dependent Nuclear Modification Factor (NMF) observed

- NMF at forward: Interplay between final state medium effects (energy loss) and entrance channel effects/kinematics

- 62 GeV data provide kinematic effects on NMF near the kinematic limit ($x_F \sim 1$)

Back-Up Slides

A_N of π^+ and π^-

BRAHMS Preliminary

π^+

π^-

x_F of π
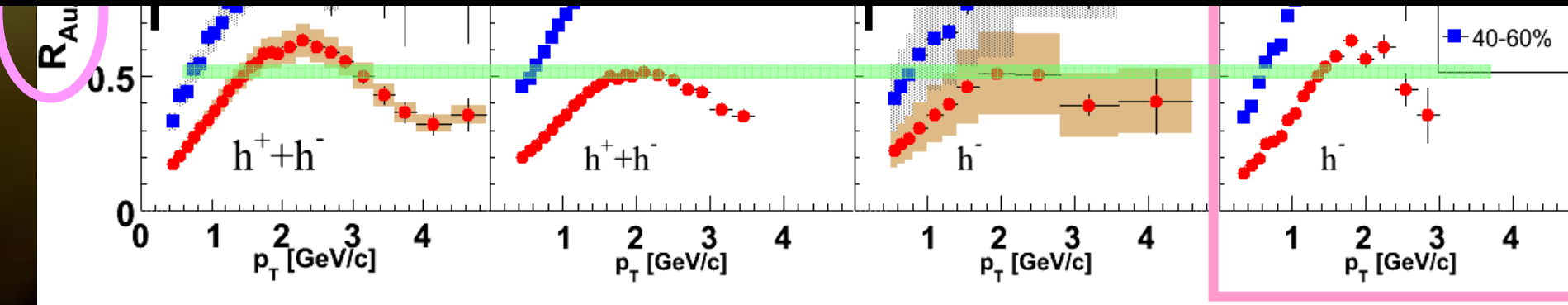
- FS (Front+Back) setting: $2.3°+2.3°$ and $4°+4°$
- Statistical errors only
- Systematic error estimated ~ 25%
- point-to-point variations include p_T-dependence of A_N from <p_T> variations in x_F bins
- $A_N(\pi^+)$: positive ~(<) $A_N(\pi^-)$: negative: 5-10% in $0.1 < x_F < 0.3$
- p_T range is limited by PID and statistics

A_N of proton and pbar
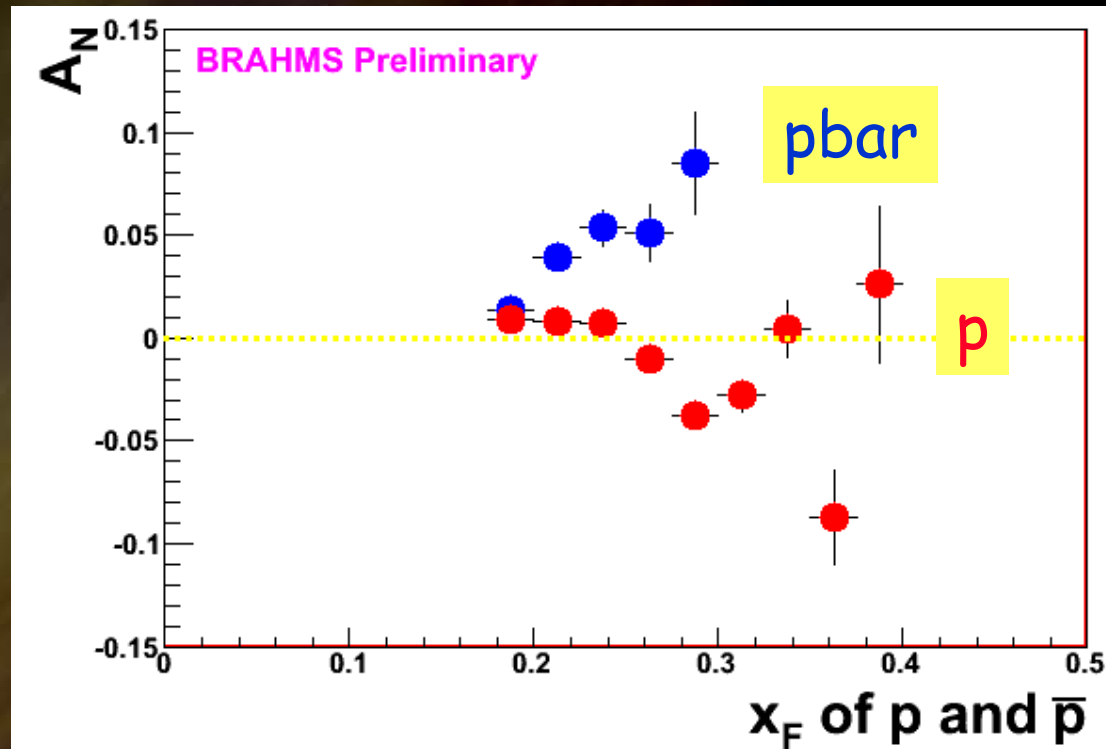
- A_N(pbar) ≠ 0 and positive
- A_N(p) ~ 0: At this kinematic region, protons are mostly from polarized beam proton, but only ones showing A_N ~0
- Need theoretical inputs

A_N for Kaons

BKK FF

BKK FF rescaled

$$D_{K/sea} \simeq D_{K/val}[D_{\pi/sea}/D_{\pi/val}]$$

K^+

K^-

A_N

A_N

X_F

X_F
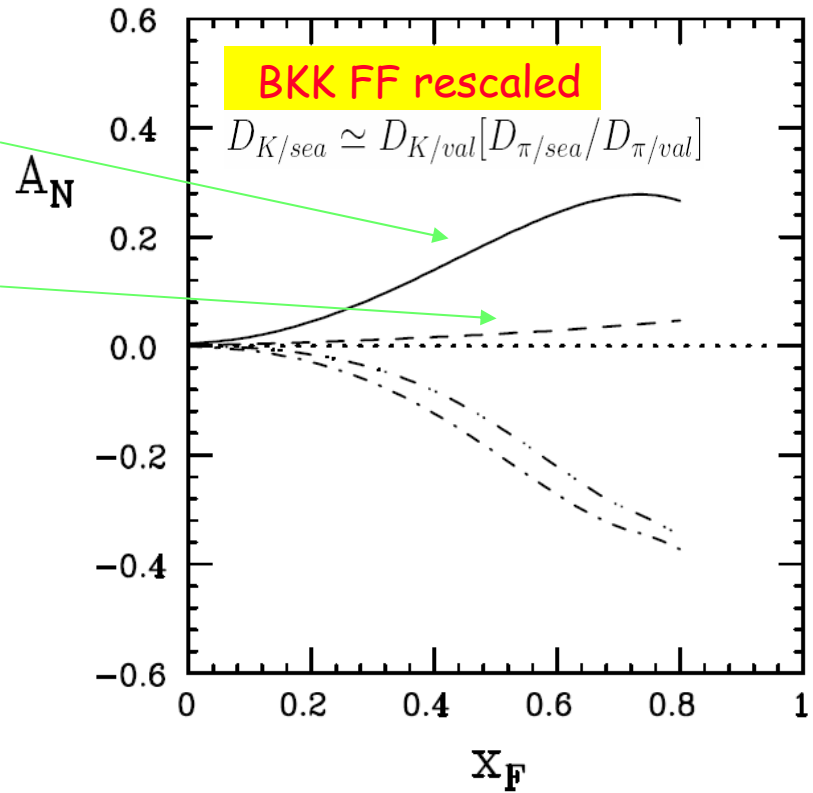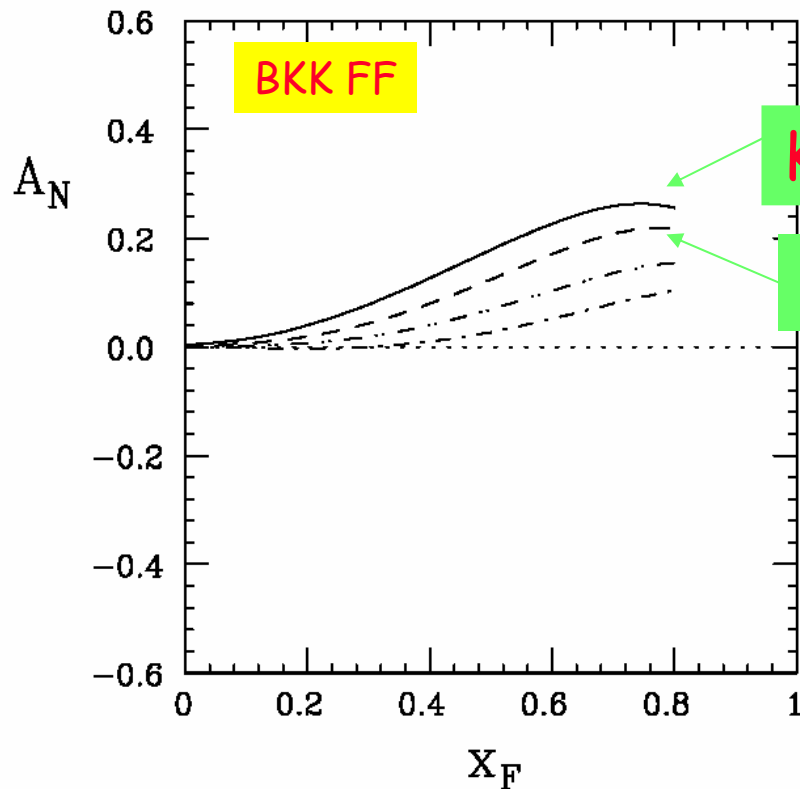
Anselmino and Murgia PLB442 (1998) 470-478

- Strong strangeness FF dependence in prediction
- If main contribution to A_N at large x_F is from valence quarks: $A_N(K^+) \sim A_N(\pi^+)$, $K^- \sim 0$
- BKK (Binnewies, Kniehl, Kramer 1995)

Determination of Single Spin Asymmetry: A_N

- Asymmetries are defined as

  $A_N = (\sigma^+ - \sigma^-)/(\sigma^+ + \sigma^-) = \varepsilon / \mathcal{P}$

- For non-uniform bunch intensities

  $\varepsilon = (N^+/\mathcal{L}^+ - N^-/\mathcal{L}^-) / (N^+/\mathcal{L}^+ + N^-/\mathcal{L}^-)$

  $= (N^+ - \mathcal{L}*N^-) / (N^+ + \mathcal{L}*N^-)$

  where $\mathcal{L}$ = relative luminosity = $\mathcal{L}^+ / \mathcal{L}^-$

  and the yield of in a given kinematic bin with the beam spin direction is N^+ (up) and N^- (down).

- The polarization $\mathcal{P}$ of the beam was ~50% in the RHIC Run-5 (Blue beam)

- Beam polarization $\mathcal{P}$ from on-line measurements: (systematic uncertainty ~15%)

Rcp at 62 GeV: Energy Conservation at Large x_F

BRAHMS Preliminary
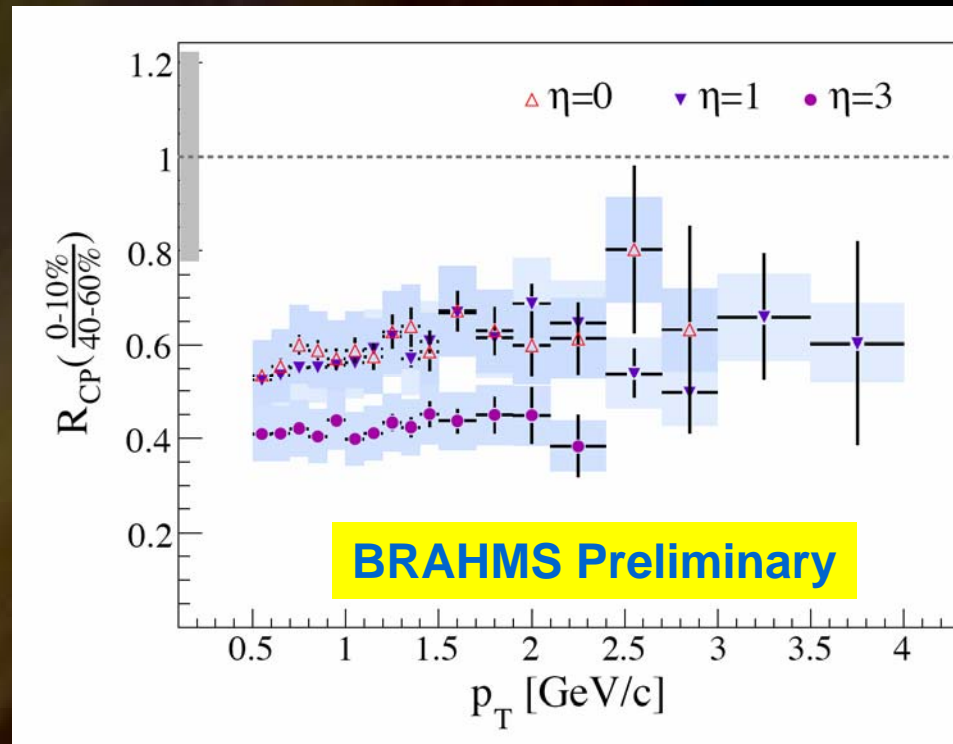
Rcp at 62 GeV < Rcp at 200 GeV at forward (y~3)
- Interplay between suppression, Cronin effect, and
- Nuclear medium dependent "Sudakov Effect" near the kinematic limit
- Cannot be due to longitudinal extension of medium
- 62 GeV pp data analysis in progress